Modelling and Design Analysis of Modified Conveyor Roller System for the Optimization of Power Consumption

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Abstract - Basically a conveyor is very important in the material handling industries but for running a conveyor system consumption of electricity is very high and proper maintenance is required. This increases the overall cost of the system especially in the heavy conveyor system. Our project is an attempt to design a system which reduces the overall cost of roller conveyor system as the system is required in many industries for the regular supply of materials. So it became very important to introduce a system which can work at very low cost with the low consumption of electricity. In this paper we have been designed a modified system to reduced power consumption. With this goal keeping in our mind design analysis of the modified system is carried out with the help of CATIA V521.

In the existing design of roller conveyor system rollers are arranged in one row which is used for handling both the light and heavy weight materials, so the power consumption is being adjusted for both the conditions (heavy and low) which takes lots of time and power .In our project the roller conveyors are arranged in two rows instead of one. In the upper row seven rollers and in the lower row seven rollers are arranged to save the power and enhance the efficiency. According to load application upper and lower rollers are engaged and disengaged automatically to save the power consumption. And same amount of power will be consumed as in the case of lightweight materials load application.

Keywords: Roller Conveyor System, Geometric modeling, Material handling, Power saving roller.

I. INTRODUCTION

A roller conveyor system is a material handling equipment that carries materials from one location to another either heavy or light weight material. Conveyors are especially useful in the applications involving the transportation of heavy or bulky materials. Conveyor system allows quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries. Many kinds of conveyor systems are available, and are used according to the various requirements of different industries.

A roller conveyor in a known manner includes a plurality of driven rollers disposed in two parallel tracks. With each driven roller a drive motor is associated. From a first voltage source a first se of the driven rollers is supplied, wherein a second voltage source is provided, from which a further set of the driven rollers is supplied. This arrangement offers a high degree of redundancy in the event of the failure of individual components of the roller drive, thereby guaranteeing an emergency operation in such a situation.

II. PROBLEM STATEMENT

Generally it has been observed that the conveyor system is used for the material transferring from one location to another location but due to the frequent change in the loading conditions. More or less power has been lost. To save the power consumption optimization is done by some design modifications in the existing design of roller conveyor system.

III. NEED OF A CONVEYOR SYSTEM

With the beginning of the 20th century bring the industrial revolution as well as much great advancement in conveyor technology. In 1901, the first steel belt was invented in Sweden. They can be installed almost anywhere, and are much safer than using a forklift or other machine to move materials. They can move loads of all shapes, sizes and weights. Also, have many advanced safety features that help prevent accidents. There are a variety of options available for running conveying systems, including the hydraulic, mechanical and fully automated systems, which are equipped to fit individual needs.

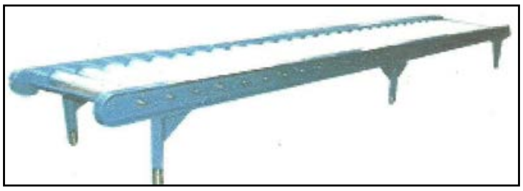

Fig. 3.1 Roller Conveyor [1]

The following are the objectives of the study:
1. Study existing roller conveyor system and its design.
2. Geometric modeling of existing roller conveyor.
3. To generate parametric model using ANSYS
4. Optimization analysis of modified roller conveyor.
5. To carry out Analysis of Modified design for same loading condition.
6. Recommendation of new solution for weight optimization.

IV.SCOPE OF THE DISSERTATION

Design analysis is carried out with the help of ANSYS and for the geometric modeling of an existing roller conveyor system CATIA V5R19 has been used .Optimization of conveyor assembly for the minimum power consumption has been carried out. Comparison between existing and modified design has been done in this dissertation work.

V. LITERATURE REVIEW

In this paper review of available literature related with the roller conveyor system, material handling equipment, design and analysis, modified none modified has been carried out.

In this paper author explained a roller conveying that includes two axially spaced supporting frames substantially parallel in the conveying direction of the conveying system, at least one roller, and one supporting shaft, each supporting shaft configured to be engaged in at least one of the supporting tubular frames to support the at least one driving roller, and at least one first supporting bearing for each supporting shaft [1].

This paper explains about the rollers and pulleys for use with industrial equipment and, more particularly, to rollers and pulleys having low-mass for use in machines using flat belts, machines for sorting and transporting mail articles, conveyor systems.

A low-mass roller is disclosed comprising a cylindrical body formed of polymeric material and having an exterior surface, first and second open ends and defining an interior tubular space along a longitudinal axis there through for receiving an axle; and an outer shell formed of thin metal covering the exterior surface of the cylindrical body. The assembly of the first and second tubular shells includes a weld ring disposed between and nested within the first respective ends of the first and second tubular shells such that the shells are held together in alignment during the welding process [2].

In fact in this first aspect the invention relates to a conveying system comprising: two axially spaced supporting frames extending substantially parallel in the conveying direction (F) of the conveying system; at least one plurality of rollers; at least one plurality of supporting shafts, each adapted to be engaged in at least one of said supporting tubular frames to support at least one roller; characterized in that each roller comprises: at least one roller body extending around a rotation axis X-X; at least one engaging seat for at least one supporting shaft, placed concentrically to said roller body, at least first removable coupling means for a second roller, a cover or a spacer.; at least a radial seat realized on the outer surface of said supporting shaft. In the present invention scope the terms “axial”, “axially”, denote a direction substantially perpendicular to the feed direction (F) of goods in the conveying system [3].

The main focus of this work is to work with concurrent engineering by modifying the existing gravity roller conveyor system designing. By modifying the arrangements of some important parts (Roller, Shaft, Bearing & Frame), to minimize the overall power consumption of the assembly and to save considerable amount of money. Gravity roller Conveyor has to convey 3500 N load, 30 inch above ground and inclined at 4 degree. Fig.3.1 shows roller conveyor assembly. Components of conveyors [20] are as follows:-

Sr. No.	Component	Material	Qty.
1	C -Channels for Chassis	ISMC 100	2
2	Rollers	Mild Steel	15
3	Bearing	Std.	30
4	C-Channels for Stand	ISMC-75	4
5	Shaft	Mild Steel	15

Fig. 5.1 Roller Conveyor assembly [20]

VI. PRINCIPAL OF WORKING

A roller conveyor consists of two or more pulleys, with a continuous loop of material – the roller conveyor roller – that rotates about them. One or both of the pulleys are powered, moving the roller and the material on the roller forwarded. The powered pulley is called the drive pulley while the unpowered pulley is called the idler. There are two main industrial classes of roller conveyors; those in general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport industrial and agricultural materials, such as grain, coal, ores etc. generally in outdoor locations. Generally companies providing general material handling type roller conveyor do not provide the conveyors for bulk material handling. In addition there are number of commercial applications of roller conveyors such as those in grocery.

VII. GEOMETRIC MODELING OF AN EXISTING ROLLER CONVEYOR SYSTEM

Geometric modeling has been carried out with the help of CATIA V5R17.

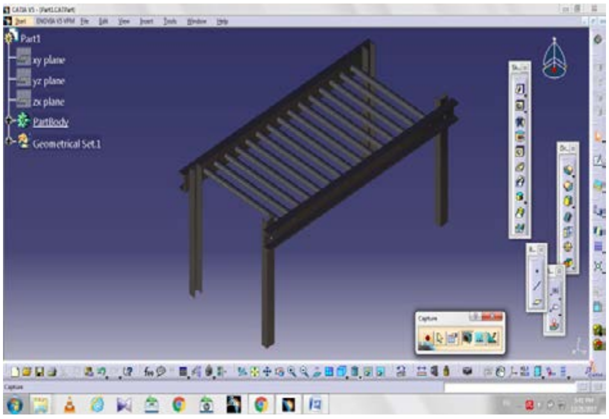

Fig. 7.1 Geometric modeling of an Existing roller conveyor system with supports

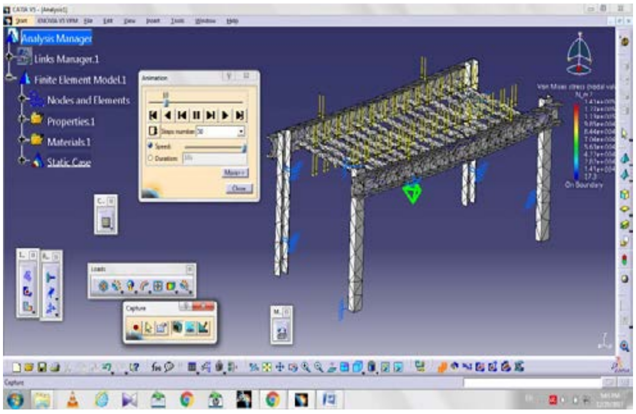

Fig. 7.2 Finite Element Mesh of the Existing Roller Conveyor System

A) Static Structural Analysis

A static structural analysis is carried out to analyse the effect of steady state loading conditions on a roller conveyor system structure, when avoiding the effect of inertia force and damping effects, because these are caused by the varying loading conditions in the given time periods. As a static analysis may include steady inertia load (such as gravity and rotational). Design and analysis of roller conveyor for power savings, weight optimization & material saving and time varying load condition that can be approximated as static equivalent loads. Properties of materials which are required for the analysis of an existing roller conveyor systems are selected**.** As we know that a Static analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that may not be induced significant inertia and damping effects. Static loading and its response conditions are such that is, the loads and the structure's response are assumed to vary slowly with respect to time.

B) Critical load condition

Load is acting on any four rollers hence by considering 3500 N load is uniformly distributed on all rollers maximum deflection, maximum stress values have been checked for existing design which has been shown and discussed in the chapter no.05 results and discussions.

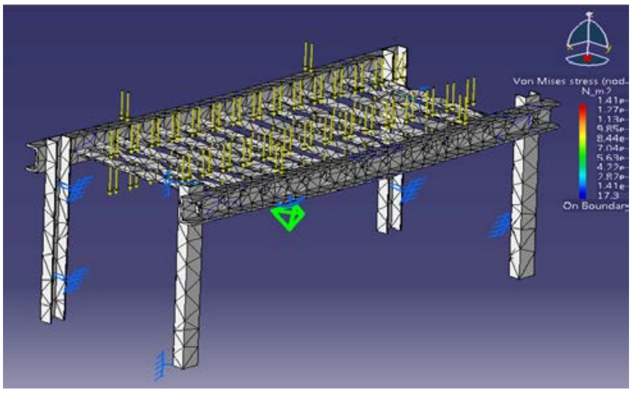

Fig. 7.3 Finite Element Mesh with the stress distribution analysis of the Existing Roller Conveyor System

VIII. GEOMETRIC MODELING OF MODIFIED ROLLER CONVEYOR SYSTEM

Geometric modeling of modified roller conveyor system has been carried out using CATIA V5R17. It has been shown with the four stands. In the modified design of roller conveyor system 14 rollers and 14 shafts are used to reduce the material cost and its utilization. In the design an attempt has been made to optimized the power consumption by using rollers in two parallel rows one upper row contains 7 rollers and one lower row contains the 7 rollers for the similar power distribution to overcome the power loss in carrying the heavy weight objects.

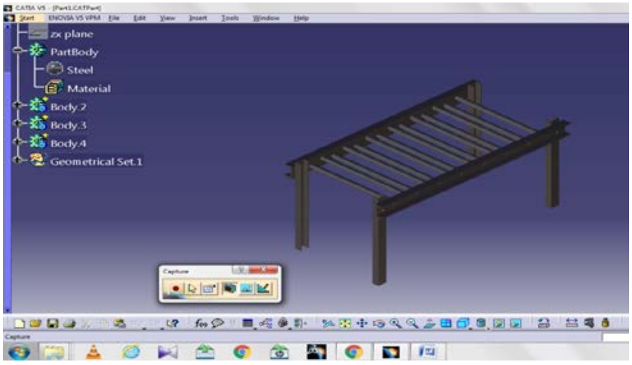

Fig. 8.1 Geometric modeling of the Modified Roller Conveyor System

IX. PRINCIPLE OF WORKING OF MODIFIED ROLLER CONVEYOR ASSEMBLY

A Modified roller conveyor system consists of two parallel rows of 14 shafts i.e. upper and lower row. In each row 14 rollers are placed, with a continuous loop of material – the roller conveyor roller – that rotates about them. One or both of the pulleys are powered, moving the roller and the material on the roller forwarded. The powered pulley is called the drive pulley while the unpowered pulley is called the idler. There are two main industrial classes of roller conveyors; those in general (light weight) material handling such as those moving boxes along inside a factory and bulk material(heavy weight) handling such as those used to transport industrial and agricultural materials, such as grain, coal, ores etc. generally in outdoor locations. Generally companies providing general material handling type roller conveyor do not provide the conveyors for bulk material handling. In addition there are number of commercial applications of roller conveyors such as those in grocery. Detailed assembly of gravity modified roller conveyor system is shown in fig.4.1.Our concept is to design such type of roller conveyor system which can be capable of handling both (heave and light weight) type of material at a time even at irregular interval without any power loss but with the optimized power consumption.

In conventional rollers, there is only one row of rollers which, do not facilitate for different kind of loading. In our project, were are providing the facility of having two kinds of loads, for lighter loads upper row works and for heavy loads both row work. The system reduces the unnecessary power consumption of running all rollers.

X. RESULTS AND DISCUSSIONS

Weight of the Existing roller conveyor system is considered as 193 kg determined by theoretical analysis which has been discussed in the table5.1 while the weight of modified roller conveyor assembly has been considered as kg detailed analysis has been shown in the table no.5.2 - Maximum deflection plot shown in fig. 5.1 - Maximum stress plot shown in fig. 5.2 Load of 3500 N is applied on 4 rollers which located at the centre of the conveyor system. We get the maximum deflection and maximum stress.

Table 10.1 Total Weight of Existing Roller Conveyor Assembly

Sr. No.	**Name of Component**	**Weight (Kg)**
1.	C-Channel for Chassis	39.066
2.	Rollers	111.1181
3.	Shafts	20.7421
4.	Bearing	2.994
5.	C- Channel for Supports	19.70
Total Weight of assembly of an Existing roller conveyor assembly		193.6121

XI. STATIC STRUCTURAL ANALYSIS

Stress analysis has been carried out for the different loading conditions. For the existing roller conveyor system load may be applied under 3000N for safe working conditions. While for the modified design of roller conveyor system load may be increased till 4000N it may work under safe mode. After the structural analysis and geometric modeling it has been clearly shown that there is a scope for the modification in weight, material consumption and power applications. So that the Existing design may be modified for the optimization of power consumption and regular weight either bulky or light weight applications.

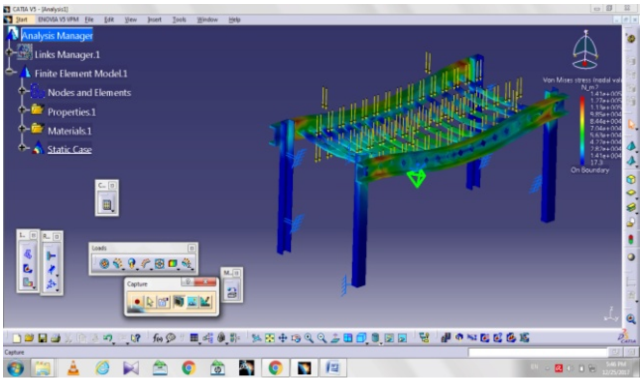

Fig. 11.1 Stress analysis of Existing Roller Conveyor System (A)

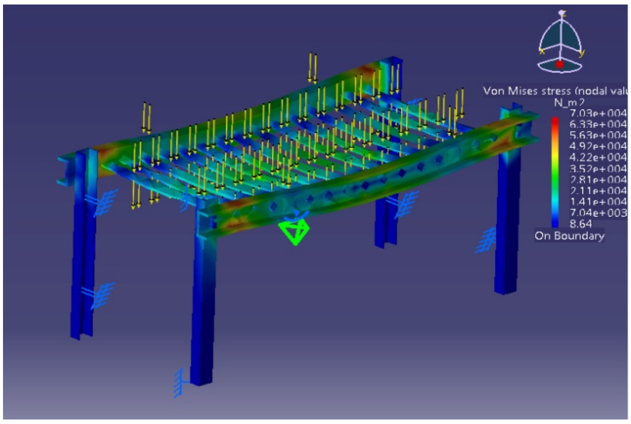

Fig. 11.2 Stress analysis of Existing Roller Conveyor System (B)

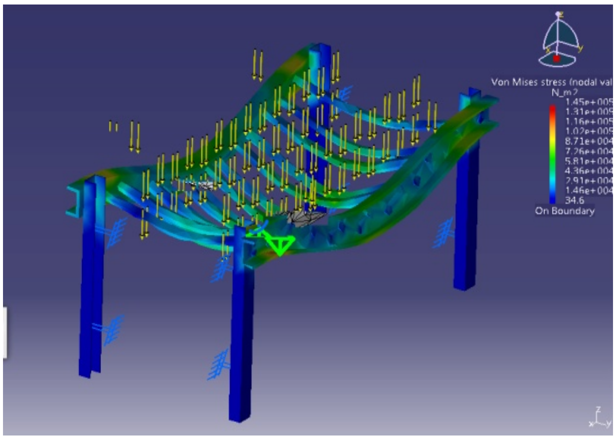

Fig. 11.3 Stress analysis of Modified Roller Conveyor System (A)

XII. POWER CONSUMPTION AND SAVINGS

We are considering a motor of 4 h.p. or 2 motors of 2 h.p. running conventional roller conveyor.

So the total power consumption in units:-

- ⇨ 2 h.p.= 2 motors
- ⇨ 1 hr consumption= 1*0.746*2 kW
  = 1.492 units

We are considering 10 hr work in a day.

So for 10 hr= 14.92 units/day

And for 30 days= 30*14.92 units

= 447.6units/month

So for 2 motors= 895 units/month.

XIII. MODIFIED ROLLER CONVEYOR SYSTEM

Now we are using 4 motors of 1 h.p. instead of 4 h.p. or 2 motors of 2 h.p. With this for calculation we are expecting that modified roller conveyor will work 5 hour for light weight and 5 hour for heavier weight:-

Thus, no of motors= 4

Power= 1h.p.

**For light load:-

1 h.p. /hr= 0.746 unit

So for,

5hr= 3.730 units

We are using two motors for upper row:-

- ⇨ For two motors= 7.460 units/day
- ⇨ For a month = 30*7.460
  = 223.8 unit/month
  **For heavy load/ when both rows are working:-
  So for all 4 motors working for 5 hour in a day. So in a month
  = 447.14 unit/month
- ⇨ Total power consumption,
  = 223.8+ 447.2
  = 671 units.

XIV. COMPARISON OF POWER SAVINGS

Conventional roller conveyor consumption

Modified roller conveyor consumption

= 895-671

= 224 units.

Table 14.1. Power Consumption

Sr. No.	**Power Consumption/Day (units)**	**Power Consumption/Month (units)**	**Power Savings (units)**
Existing Design	14.92	447.6	---
Modified Design	7.460	223.8	224

XV. CONCLUSION

Roller conveyors operate in airports, underground stations, department stores, and other commercial and public buildings. Safety is very greater than the requirement and there is a scope for weight reduction and consequently power consumption reduces through the modified design. In which number of components are not reduced in a very large amount but due to the modifications in the design these are rearranged in such a manner that they can carry maximum load and with the reduction of weight of the assembly. It has been shown in the Fig.15.1 It has been observed that

Critical parameter which reduces the weight of Channels are as follows:

- Roller outer diameter
- Roller thickness.
- Though value of deflection, stress is more in case of Modified design, but it is allowable.
- 4.63% of weight reduction is achieved due to modified design it is not considerable as the modification is not done only for the weight reduction but for the power optimization. Due to the modification power has been saved.
- 8.63 Kg. weight reduction achieved by optimized design than existing design.

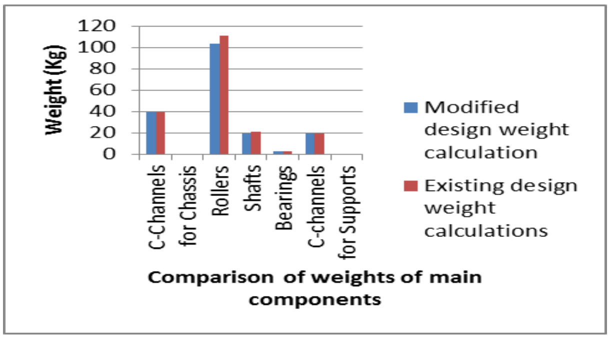

Fig. 15.1 Weight comparison of Existing and modified design

Effect of loading conditions on certain parameters like deflection, natural frequency and max. Stress in the Existing design and Modified design can be shown on the Fig. 15.2.

It has been observed that Max. Deflection for the modified design is more than that of an existing design it is 0.33mm for the existing while it is 0.4467mm for the modified design.

In case of max. Stress it may be observed that in the existing design it is less than that of modified but in the modified it is allowable.

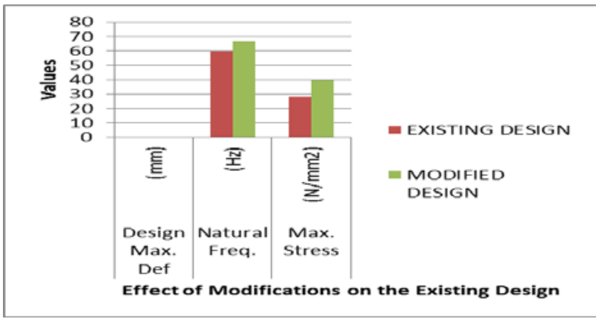

Fig. 15.2 Effect of loading on the design

Roller conveyors are widely used to load and unload ships, trucks, and railway trucks. One such system moves over 5.400 metric tons of coal an hour in a steady stream from railway trucks to the belt. The belt carries the coal to a loading tower that distributes the coal to the various parts of a ship. Roller conveyor systems are used for carrying the light and heavy weight material handling. Although the Existing roller conveyor may carry heavy weight and with power loss may carry light weight material

But in the modified design power savings is optimized. In the Existing design it is much higher due to the engagement of all the rollers at a time but in the modified design all the rollers are not engaged at a time but the upper rollers are engaged once for the lightweight materials and simultaneously for the same power utilization all the 14 rollers from the lower and the upper rows are engaged to convey the heavy weight material along with the savings of power.

It has been shown already in the chapter no.4 in the geometric modeling section.Fig.15.3 shows the comparison of power consumption in the Existing and modified design.

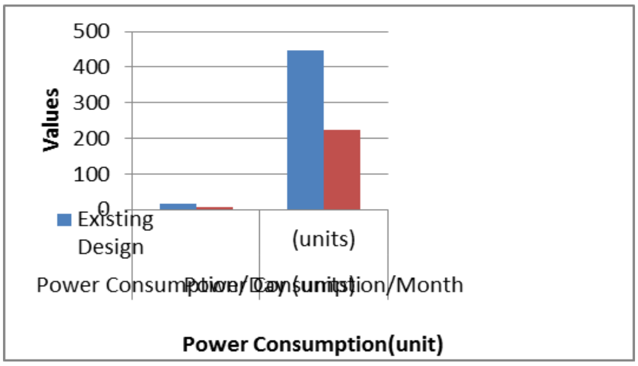

Fig. 15.3 Power Consumption comparisons

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